

# Thinking Universal Dynamics

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## The universal structure of human thinking

Two problems

1. How to build a truly fundamental physical theory
2. How to build a general theory for all kinds complex systems in physics, chemistry, biology, sociology, linguistics, cognition,...

leads to the same question:

What is the minimum amount of a priori structure which one needs to build on it a theory of the world?.

- A physical theory will be the more fundamental the less structure is assumed *a priori*
- A theory of complex systems will be the more general the less structure is assumed *a priori*

Einsteins principle of relativity is a statement of *absence of a priori structure*.

Q: What would be the minimum?

A: structure of human thinking

**Pre-Axiom:** *The human mind thinks about relations between things or agents.*

Networks of things or agents and relations are called **systems**. One is lead to a theory of structure and of structural transformations.

(Trying to “deduce” the structure of human thinking from neurophysiological data makes use of the structure of our thinking, so it is not a deduction, but a self consistency requirement)

## How does one describe structure?

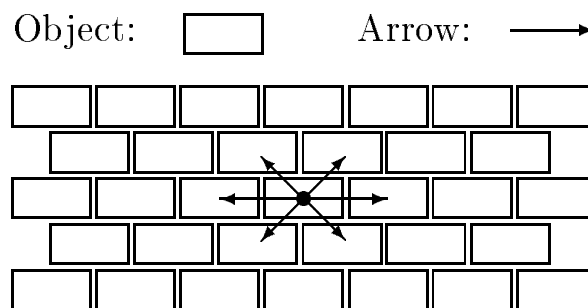


Figure 1: Brick wall as system of objects and relations

### Lessons

1. structure is described as a network of relations between objects.  
The relations are represented by arrows.
2. Arrows can be composed. Some arrows are considered as fundamental, all others can be composed from fundamental arrows
3. Among the relations (arrows) is identity of an object with itself
4. Every arrow determines an an arrow in the opposite direction  
(Elfi is my wife, therefore I am her husband...)

## Composition of arrows

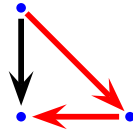


Figure 2: A composite arrow becomes fundamental

### Examples of composition of arrows from more fundamental ones

- friend of a friend
- brother in law = husband of sister
- creative advertising:

Relations are associations. Want to construct composite ones

$$\text{product} \mapsto \text{good!} \mapsto \text{I want it} \quad (1)$$

from **preexisting relations** like

$$\text{product (e.g. light clothing)} \mapsto \text{beach and sunshine} \mapsto \text{good!} \quad (2)$$

- Spinoza's ethics
- Enzymatic action in biochemistry
- Logical or mathematical deductions:  
( $\mapsto$  means "implies")  
If  $A \mapsto B$  and  $B \mapsto C$  then  $A \mapsto C$
- Motion in space

- Dynamical laws in physics: matter (Dirac fields) electromagnetic fields (Maxwell's equations)

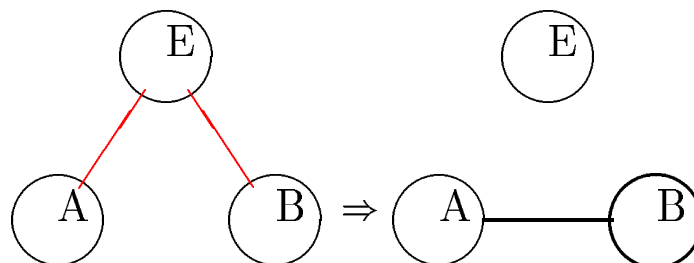


Figure 3: **Catalysis in chemistry.** Enzyme E binds molecules A and B. First a substrate-enzyme complex is formed where A and B are bound to E. Then the composite link between A and B is transformed into a fundamental one

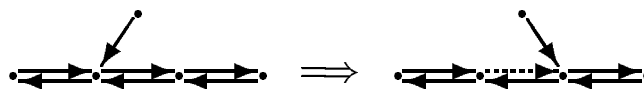


Figure 4: Interpretation of **motion as transformation of a composite relation into a fundamental one.** The objects which are connected by bidirectional links are interpreted as space points, and the other object as a particle (or as “the idea of matter”). The link from the particle to a space point  $x$  represents the relation of “being at  $x$ ”. Motion takes place when a composite arrow made from the relation  $b$  of the particle to its former position, and a relation of this space point to a neighbor is declared fundamental, while  $b$  loses this status.  $b$  remains as a composite arrow.

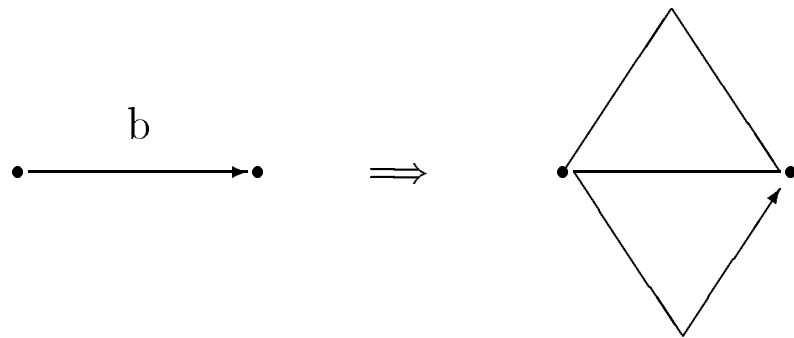


Figure 5: **The universal equation of motion of fundamental physics.** The symbol  $\Rightarrow$  symbolizes the effect of one time step. The Dirac equation for matter is a special case

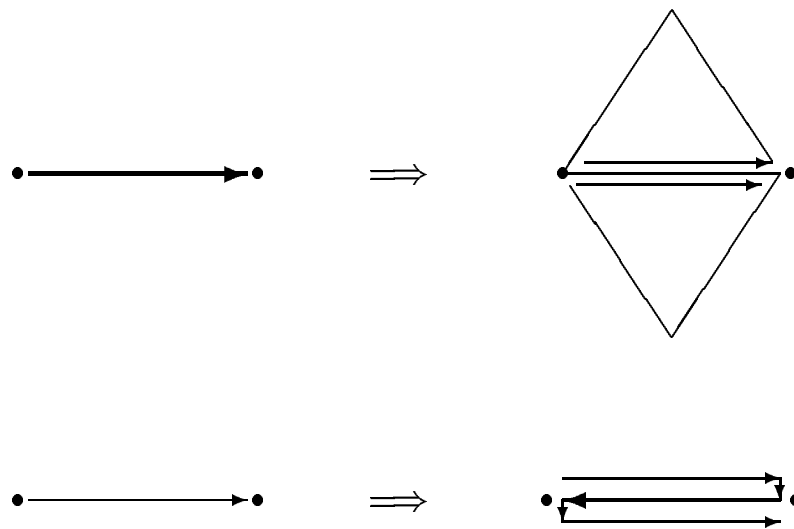


Figure 6: **Maxwell Equations of Electrodynamics,** Yang Mills equations of elementary particle physics. In the presence of Dirac matter, the triangle can have a tip at  $\infty$ .

In gauge theories like Maxwells theory of electromagnetism, a general form of Einsteins principle of lack of *a priori structure* is valid, and the consistency with that implies conservation of electric charge.

**The indestructibility of matter comes out from a structural description!**

There is only one algebraic operation  $\circ$  - composition of arrows which

can be used to formulate dynamical laws.

## Besides Motion there is Growth

It uses the fact that every arrow determines an arrow in the opposite direction.

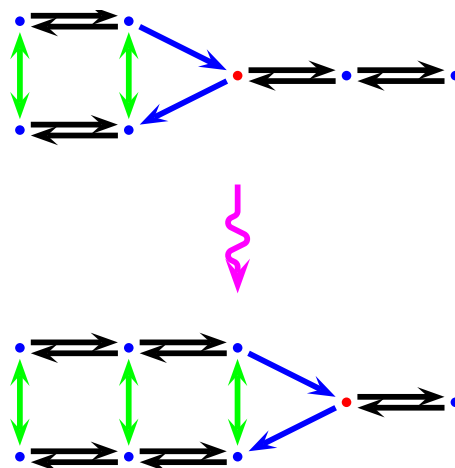
### Example: Reproduction fork dynamics

This kind of dynamics is the basis of biological life on earth. It governs DNA replication during cell division.

It is a universal copy machine for **any** structure

Composite substructures are copied just the same (“Multiscale”)

The red objects are designated to be split in the next move



## Universal Dynamics

is dynamics which is defined for **every system** without any need of further specification.

Given some system (network of objects and relations), a dynamical law fixes the network which is present at the next instant of time. Sorin proposed to call it a **Drama**

The dynamics is supposed to be local, i.e. what becomes of an object or fundamental arrow depends only on the fundamental arrows incident on

them. This generalizes the locality principle in physics. It is something that AI people had missed.

Because of locality, a universal dynamics is buildt from “atoms” - the local action of the dynamics on some object and its fundamental arrows. I cll them **Enzymes**. They are declared objects, since they are (act) “somewhere” in the system.

An enzymatic theory of computation is being developped. A general problem solving strategy is a universal dynamics supplemented with local cost functionals which define an optimization problem.

## Cognition

is based on finding structure preserving maps from one system to another

There are isomorphism classes of structure, and more general maps determined by generative grammars.